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PHYSICO-CHEMISTRY OF GEOPHAGIC SOILS INGESTED TO RELIEF NAUSEA AND VOMITING DURING PREGNANCY

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Abstract

Background: Nausea and vomiting during pregnancy (NVP) is one of the most common symptoms experienced by most women during their first trimester of pregnancy. For some of these women, especially the more tribally and culturally oriented ones, soil ingestion is one of the remedies used to curb NVP. The aim of this study was to physico-chemically characterise selected geophagic soils from Cameroon and South Africa, ingested for the relief of NVP and to appraise their ability to meet the needs of geophagic individuals.
Materials and Methods: Thirteen geophagic soil samples (6 from Cameroon and 7 from South Africa) were obtained from traditional mine sites and physico-chemically characterized. The following tests were conducted; particle size distribution (PSD), liquid limit (LL), plastic limit (PL), plasticity index, soil pH and electrical conductivity (EC).
Results: The samples were texturally classified as silt loam, of medium to high plasticity with normal to active swelling potentials. The samples were generally acidic (pH of 3.1 – 6.1) with low EC (average of 92.71µS/cm).
Conclusion: Based on soil consistency limits and pH, the samples were found to be suitable for use as remedy for NVP with soils from Cameroon displaying the most optimum properties.

Key words: Geophagia, salivation, soil plasticity, acidity, nausea.

Introduction

The deliberate ingestion of soil (geophagia), is an ancient practice observed among peoples on all continents (Hunter, 1973), particularly pregnant and lactating women (PLW), of all ages, educational level and socio-economic status notwithstanding (Reid, 1992; Abrahams and Parsons, 1997). Although classified as a medical condition by the World Health Organization (WHO, 1996), soil ingestion is considered as a culturally sanctioned practice with inferred psychosomatic benefits such as nutrient supplementation, detoxification, anti-diarrheal, and relief from *morning sickness* associated with pregnancy (Mahaney et al., 2000; Shinondo and Mwikuma, 2008; Ngole et al., 2010; Ekosse et al., 2010).

With respect to nausea and vomiting during pregnancy (NVP), otherwise known as *morning sickness*, Madjunkova et al. (2013) reported that up to 85% of women will have nausea and/or vomiting between 12 and 16 weeks of pregnancy, while 20% may experience symptoms at 5 months or even at time of delivery. In general, NVP appears between the 4th and 6th week of gestation with peaks observed between weeks 8 and 12, respectively (Lacasse et al., 2009). The severity of NVP symptoms may vary from mild to severe (*hyperemesis gravidarum*), with the more severe form affecting up to 27% of pregnant women (Lacasse et al., 2009). According to Godwin (2002), the aetiology of NVP is poorly understood but could be viewed as a multifactorial problem with hormonal, vestibular system, gastrointestinal, psychological, hyper-olfaction, genetic and evolutionary factors as possible causes. A number of researchers and medical practitioners have suggested various medications as well as dietary and lifestyle changes as remedy for NVP (for example see Madjunkova et al., 2013).

However, to the more traditional and culturally oriented women soil ingestion has been and continues to be the most cost effective, widely accepted and adopted remedy for NVP despite some instances; their knowledge of possible risks associated with the practice (Shinondo and Mwikuma, 2008). Typical health risks include but not limited to; chemical toxicity, iron deficiency anaemia (Mogongoa et al., 2011), hypokalaemia (Key et al., 1982), excessive tooth wear, enamel damage and erosion of the mucosal surface of the stomach, perforation of the colon (King et al., 1999), parasitic infections such as transmission of *Ascaris lumbricoides, Trichuris trichuria,* (Saathoff et al., 2002) and other highly toxigenic bacteria (*Clostriduim perfringens*, *Clostridium tetani*, *Clostridium botulinum*) causative agents of gas gangrene, tetanus and boitulism (Bisi-Johnson et al., 2010).

For these traditionally oriented peoples, the choice of soil over a more conventional alternative treatment for NVP is based on their belief systems premised on cultural themes like; soil represents fertility, belonging to a *place* and the continuity of lineage (Geissler, 2000). Thus far, very few studies have focused on characterization of geophagic materials (Mahaney et al., 2003; Ngole et al., 2010; Ekosse et al., 2010). In this study inherent physico-chemistry of selected geophagic soils from South Africa and Cameroon ingested for relief of NVP has been ascertained and their ability to meet the needs of the geophagic individuals appraised.

Materials and methods

Thirteen geophagic soil samples; 6 from Cameroon (CM1 – 3, 5 - 7), and 7 from South Africa (SA 1 – 7), were obtained from traditional mine sites and physico-chemically characterized. Tests conducted includes; particle size distribution (PSD), liquid limit (LL), plastic limit (PL), plasticity index, soil pH and electrical conductivity (EC).The PSD was determined by laser diffraction technique using a Malvern Mastersizer Hydro 2000 Mu particle size analyser, following methods discussed in Fitzsimmons et al. (2009). Atterberg limits were determined for the fine mortar fraction (< 63 µm) using a Cassagrande apparatus following methods described by Cassagrande (1948). Between 50 and 70 g of previously prepared fine mortar was spread in a cup (maximum thickness = 1 cm), and divided by a standard axial groove. The LL is the water content expressed as a percentage by weight of the mortar after drying in an oven at 105 $^{\circ}$C, at which the groove closes over a length of 1 cm under the influence of 25 blows. The blows were produced by allowing the cup to drop from a height of 1 cm onto a hard surface. Crucibles were used to weigh the mortar before and after drying. Liquid limit was calculated from the expression;

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$$LL = (W – T) – (W_d – T)/ (W_d – T) × 100 \quad (1)$$

Where: W = Moist weight of mortar + (T), W_d = Dry weight of mortar, T = Weight of crucible.

Plastic limit (PL), is the transition from the plastic state to the solid state. In order to determine the PL 15 g of the fine mortar was used. Using the palm, the mortar was rolled on a flat surface until the tread of fine mortar broke into sections of between 1 and 2 cm long, after being reduced to a diameter of 3 mm. The PL was expressed as a percentage by weight after oven drying at 105 °C following equation (1). Plasticity index (PI) was obtained from the arithmetic difference between LL and PL. Hydrogen ion concentration (pH)(H_2O), was determined with a pH meter (Hi 9321 Micro Processor), whereas EC was determined with a Metler Tolledo EC meter (Tan 1996).

Results and discussions

Soil texture, consistency limits and NVP

Table 1 summarizes the physicochemical properties of the studied soil samples. Geophagic individuals are influenced by the texture of geophagic materials, with a preference for soil that is soft, silky or powdery. The soil samples have been texturally classified as silt loam (Fig 1), suggesting the impartation of an undesirable gritty feel during mastication due to the relatively high amounts of silt-size fractions.

Table 1 Physico-chemical properties of geophagic soils

Sample	Sand mass % (> 63 µm)	Silt mass % (63 µm – 2 µm)	Clay mass % (< 2 µm)	Atterberg Limits (mass) %)			pH	EC (µS/cm)
				LL	PL	PI		
CM 1	43.2	48.7	8.1	54	45	9	4.8	6.4
CM 2	38.0	52.2	9.8	55	44	11	4.9	5.3
CM 3	14.1	67.8	18.1	50	36	14	5	5.4
CM 5	27.9	55.9	16.2	57	40	17	4.8	12.1
CM 6	8.1	72.4	19.5	58	43	15	4.8	10.4
CM 7	4.8	75.7	19.5	60	43	17	4.8	12.4
SA 1	34.1	55.1	10.8	43	30	13	4.4	32.2
SA2	33.1	55.2	15.7	40	32	8	4.7	15.1
SA3	46.8	42	11.2	42	31	11	4.6	16.8
SA4	18.2	64.8	17	36	26	10	6	42.9
SA5	5.3	74.3	20.4	67	47	20	6.1	10.3
SA6	43	45	12	39	28	11	3.5	485
SA7	21	60	19	52	40	12	3.1	551

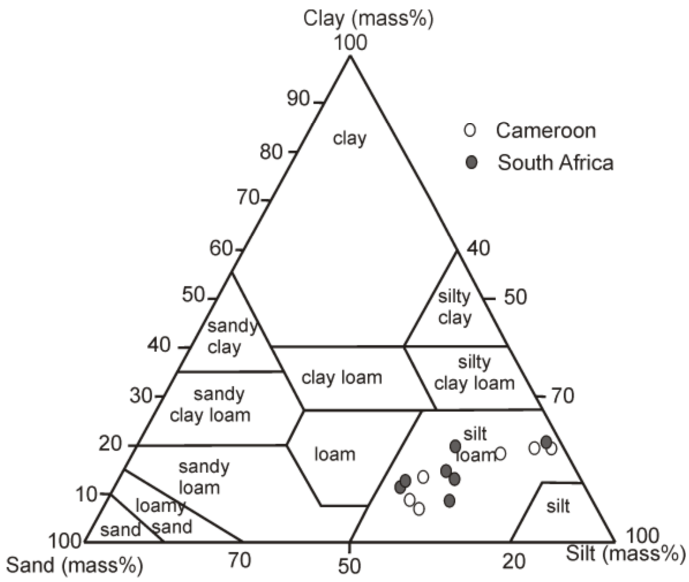

Figure 1: Textural classification of geophagic soils from Cameroon and South Africa

One of the most common symptoms of NVP is excess salivation ascribed in part to increase hormonal secretion (human chorionic gonadotropinand/or oestrogen), especially during early pregnancy. According to Madjunkova et al. (2013), it is preferable to spit out excess saliva since swallowing may enhance nausea and/or vomiting. However, for some pregnant women the discomfort and perceived psycho-social stigmatisation associated with excessive salivation especially in public places often serves as a deterrent encouraging swallowing as opposed to spitting out. For geophagic individuals under such circumstances ingesting soil provides the much needed relief.

The use of soil to reduce salivation is defined by its ability to absorb moisture during mastication. This property of the geophagic material is based primarily on its consistency which in turn depends on the PSD, type and amount of clay minerals and swelling potential of the soil (referred here as coefficient of activity) (Diko et al., 2012). The term clay within the context of this study is restricted to a particle size

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description with grain diameter of < 2 µm. In the absence of mineralogical data (which otherwise, provides a more comprehensive appraisal of the type, amount and implication of clay minerals on moisture absorption potential) consistency and swelling potential of the geophagic materials were inferred from their Atterberg limits and amount of clay-sized fractions (Diko et al., 2012). According to Fall and Sarr (2007), and Mugagga et al. (2011), by comparing soil PI and amount of clay-sized fraction (< 2 µm) present, the activity or expansivity of the soil can be quantitatively described. Depending on how much moisture the soil can retain it would exist in any of the four states; solid, semi-solid, plastic and liquid. For each state, the consistency and behaviour of the material is different and so are their ability to reduce salivation and ultimately nausea. Generally, soil with a plastic consistency is most effective in this regard.

From the results, the samples display medium to high plasticity (Fig 2a) with a normal to active swelling potential (Fig 2b). Despite inferred grittiness of the soil samples, their consistency limits suggests increasing suitability for use as a remedy for excessive salivation, with samples from Cameroon displaying the most optimum. By ingesting dry soil and increasing its resident time in the mouth, the state changes from solid, through semi-plastic to plastic depending on how much moisture it can retain – thereby leaving the mouth dry (Ngole et al., 2010) .

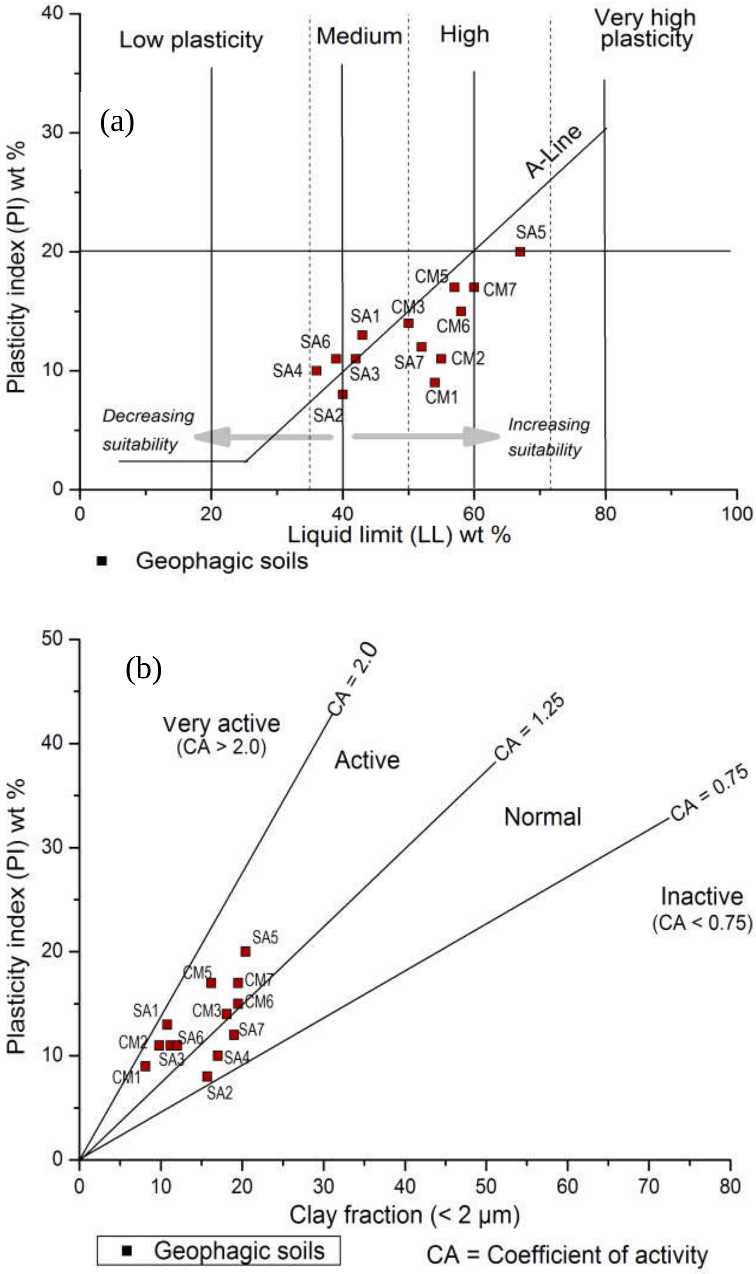

Figure 2: Soil consistency (a) and activity diagram (b) of geophagic samples from Cameroon and South Africa.

Soil pH, EC and NVP

Besides soil consistency, soil taste has been associated with reduction of excessive salivation (Ngole et al., 2010). Ibeanu et al. (1997), reported the consumption of clay to control excessive secretion of saliva during pregnancy among women in Kenya and Nigeria. The use of soil to control secretion of saliva during pregnancy as reported by some women was linked to the sour taste of the soil which in turn is related to soil pH and dissolved salts content. According to Abrahams and Parsons (1997), soil acidity is responsible for imparting the much desired sour taste in geophagic materials. From Table 1, pH ranged from 3.1 to 6.1 with about 77% of the samples recording values below 5. The pH of human saliva varies between 5 and 8 (Omen et al., 2000) therefore, ingesting these soil samples may contribute towards reducing pH in the mouth, thereby increasing acidity in the oral cavity with resultant inferred benefits such as decreased salivation. On the other hand, with the exception of SA6 and 7, the samples exhibited very low EC, suggesting low amounts of dissolved salts. The taste of these samples is therefore not likely to have been influenced by the salt content.

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Conclusion

The aim of this study was to physico-chemically characterise selected geophagic soils from Cameroon and South Africa, ingested for the relief of NVP and to appraise their ability to meet the needs of the geophagic individuals. Findings suggest, despite inferred grittiness of the soil samples, their consistency limits displayed increasing suitability for use as a remedy for excessive salivation, with samples from Cameroon recording the most optimum. Upon ingestion, the soil changes from solid through semi-plastic to plastic by absorbing excess saliva in the oral cavity, leaving the mouth dry – thus alleviating NVP in the individual. The ability of the soils to decrease excessive salivation was further enhanced by its sour taste imparted by soil acidic pH.

Acknowledgement

Particle size analysis was performed at the University of KwaZulu-Natal whereas Atterberg limits tests; pH and EC were carried out at the Soil Science Laboratory of the University of Limpopo.

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